Turbulent flows in packed beds

Turbulent flows in beds composed with non-spherical particles: model enhancement and analysis

M, Mqbas, M. Kraume*, Chair of Process and Chemical Engineering , Technical University of Berlin*

In Short

- DNS investigation of the flow topology in packed beds.
- Understanding the influence of particle geometrical properties on the dominating flow structures in packed beds.
- Enhancement of turbulent heat flux prediction in packed beds using RANS models.

Efficient design of randomly packed beds requires a deep understanding of the flow dynamics and heat transfer in the bed. Due to the recent advancements in computational methods, numerical simulations evolved into a valid alternative for the experimental approach used over the last decades to design randomly packed beds. However, modeling the fluid flow within the bed is challenging due to the simultaneous occurring of various mechanisms (chemical reactions, mixing, radiation, etc) over multiple scales. These mechanisms are influenced strongly by the turbulent structures within the pores between the bed particles. Nevertheless, the combination of complex geometrical configuration and flows with high Reynolds numbers resulted in a lack of understanding the turbulence dynamics fundamentals and its modeling accuracy in the packed bed.

The flow within the packed bed contains a wide spectrum of scales in time and space which increases drastically the computational cost of modeling. The flow field within the bed exhibits different patterns including swirling behavior, segmentation and reattachment at the surface of the particles, and flow channeling in the vicinity of the confining walls [1]. These flow structures are influenced by the interaction between the flow and the bed and has a direct effect on the temperature distribution since the thermal energy in a packed bed is transported by strong convective span-wise flows while the fluid moves through the domain [2]. Even though, the available literature is focusing on the turbulence modeling accuracy and flow dynamics in packed beds consisting of spheres, in industrial and natural applications the existence of packed beds with non-spherical particles is dominant. Additionally, the relation between the influence of non-spherical particles shape (examples in Fig. 1) on the turbulence and heat transfer remains unknown.

The aim of this project is to use obtained data from DNS simulations to enhance the accuracy of RANS modeling via estimating the model constants for flows within the packed bed. Furthermore, the Proper Orthogonal Decomposition (POD) algorithm is going to be applied on the flow quantities predicted by the enhanced RANS model to investigate and quantify the relation between particles global geometrical properties and the dominating flow structures. Therefore, giving an insight into the coupling between thermo-hydrodynamics and the geometrical configuration of the packed bed. The proposed project will contribute to improving the accuracy of predictions in which interest engineers in process engineering and will enable to take a step towards the enhanced design of randomly packed beds.

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https://www.verfahrenstechnik.tu-berlin.de/menue/ueber$_{u}ns/fachgebietsleitung/$

More Information

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[2] A. Zabaleta, M. Coussirat, M. Larrayoz, F. Recasens, E. Egusquiza *J. Chem. Phys.* **60**, 1733-1742 (2005).

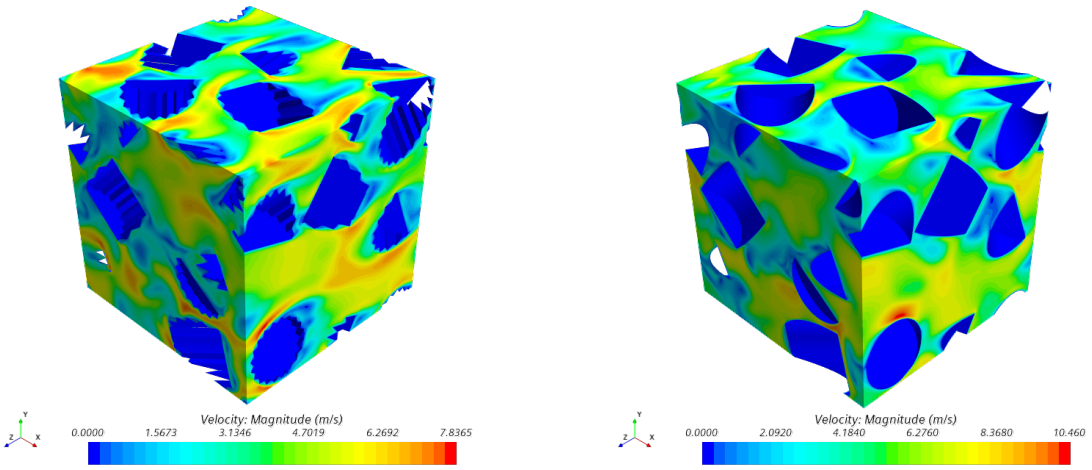

Figure 1: *Examples of velocity distribution in tri-periodic volume representing packed grooved and smooth surface cylindrical particles.*